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EARTHWORMS *as* PESTS *and* OTHERWISE

EARTHWORMS are both useful and injurious. They contribute to the enrichment of the soil by opening up the subsoil and improving the physical condition of the land, and they furnish the most widely used bait for fishing in inland waters.

They prove objectionable in lawns and golf courses, however, by their habit of building up mounds of earth at the entrance to their burrows, which break the smooth surface desired both for appearance in the lawn and for the needs of the game on the golf links.

In this bulletin instructions will be found for collecting fishworms and for keeping them and raising them in large numbers for sale; and, also, for those who are not interested in their useful side, this bulletin gives directions for exterminating them in lawns, golf greens, and flower beds.

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EARTHWORMS AS PESTS AND OTHERWISE

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GOOD AND BAD POINTS OF EARTHWORMS

EARTHWORMS are the most familiar inhabitants of the soil. Although present in almost all soils, they abound in heavy soils; and in the United States they are especially plentiful in old lawns and grasslands throughout the humid regions. The publication by Charles Darwin in 1882 of a treatise, The Formation of Vegetable Mould Through the Action of Earthworms,[1] resulted for a long time in the general view that they were entirely beneficial in so far as the welfare of man was concerned. During recent years, however, this opinion has undergone considerable modification owing to interference caused by earthworms in the maintenance of lawns and especially to their common occurrence on golf greens, where their castings form lumps or irregularities that interfere seriously with the play. The rapid popularization of the game of golf and the consequent recent multiplication of golf courses throughout the country have led to an ever increasing demand for information regarding methods of destroying earthworms.

There is also a constant demand for information of quite a different kind, which relates to the culture and care of earthworms for commercial purposes or for use in angling. An account of these worms from both points of view is therefore given in this bulletin.

Earthworms belong to a somewhat lowly organized group of animals known to science as the small-bristled roundworms.[2] Most of them, as their name implies, live in the soil; but some kinds of earthworms inhabit either the water or the soil, and some, comprising a considerable group, are able to live constantly in the water. Only earthworms inhabiting the soil are considered in this bulletin, and of these the kinds or species belonging to a family called the Lumbricidae are of chief significance. Fully matured members of this group constitute what are variously known throughout the country as angleworms, dewworms, night

[1] DARWIN, C. THE FORMATION OF VEGETABLE MOULD, THROUGH THE ACTION OF WORMS, WITH OBSERVATIONS ON THEIR HABITS. 326 p., illus. New York. 1882.

[2] Oligochaeta.

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crawlers, earthworms, fishworms, rain worms, etc. The last term is a translation of the German common name and is a very appropriate one, as these creatures crawl from their burrows by tens of thousands during heavy rains at night, especially in early spring. The negro boys of Washington, D. C., are said to call them "night lions" or "night-walkers."

Earthworms thrive in almost all kinds of soils but they prefer those containing considerable organic matter and they must have abundant moisture. For this reason they are least numerous in very sandy areas. They commonly inhabit the upper 18 inches of the soil, but Darwin has shown that they may descend as much as 6 feet, or even more, when necessary. He showed also that these worms constitute an important agency in maintaining fertility by bringing to the surface, in a finely divided state, large quantities of soil from beneath, mingling with it half-decayed leaves and other organic matter, and thus aiding in the maintenance of the conditions necessary for vigorous plant growth. Earthworms increase the nitrifying power of soils and, in short, put the soil in better physical and chemical condition for plant growth. It was estimated that in parts of England the quantity of earth thus excavated in one year amounted to 10 tons per acre. This upward transference of earth by worms also causes large and small stones to sink gradually into the soil, and instances are cited where in the course of 30 or 40 years very stony fields were converted by such means into smooth sod where scarcely a stone was visible. In point of fact, it was Darwin's conclusion that "It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures." It is apparent, therefore, that in their proper place earthworms are beneficial to agriculture. Like many other animals, however, they do not recognize man's desires, and frequently invade locations where they are not welcome.

FOOD OF EARTHWORMS

Earthworms feed partly on the soil. They swallow great quantities of earth, from which they digest the organic matter, both animal and vegetable. Their digestive apparatus is equipped with a gizzard-like organ by the aid of which they are able to grind up the tougher fragments of food. Darwin has shown that they are fond of either raw or cooked meat, seem especially eager to devour fat, and will eat sugar readily.

The mouth of the earthworm is devoid of teeth or other biting or gnawing apparatus, and consists of a simple sucking or grasping mechanism which is well supplied with powerful muscles. When an angleworm wishes to grasp any small object such as a blade of grass or a twig, it thrusts from its mouth an appendage which corresponds roughly to the tongue of a human being. This is used to oppose the snout of the worm just as one presses his thumb against his index finger, enabling it to grasp firmly any slender object. If the desired object be convex and of considerable bulk, this same tongue-like organ forms itself into a sucker which by atmospheric pressure sticks to any smooth surface, thus enabling the worm to move objects such as pebbles weighing even as much as 2 ounces. At least one kind of large tropical earthworm is able to make this sucking organ of assistance in climbing trees.

By the use of the apparatus just described the earthworm is enabled to draw leaves or other objects into its burrows. Fresh leaves are frequently taken into the burrow, and the worm then moistens the innermost ends of them with a secretion from its mouth, which starts fermentation and soon renders the leaves sufficiently tender to enable it to tear off fragments for its food. Among the favorite tree

leaves thus treated are those of the wild cherry, lime, elm, and maple, while of the cultivated plants carrot, celery, cabbage, onion, horseradish, and turnip leaves seem to be preferred. Not infrequently blades of grass are eaten.

Earthworms have been accused of biting off young plants and dragging them into their burrows; but, if we may judge from the construction of their mouths, they are incapable of actually severing fresh growing plants. They are, however, very muscular and strong, and a large earthworm with its bristled tail firmly fixed within its burrow is able to exert a force quite sufficient to uproot delicate small plants. Instances have been observed where seedling plants of various kinds have been thus pulled up. Serious injury of this character to gardens has been reported from this country and Germany. That earthworms are actually responsible for any extensive, serious injury to larger garden plants seems highly improbable, as they are numerous in nearly all gardens, including those that show no injury.

HABITS AND SENSES

Earthworms crawl by means of alternate contraction and expansion of the muscular rings forming their bodies. In these movements they are helped by rows of very short, stiff bristles, placed along the sides of the body. When in their burrows they use these bristles as an important aid to locomotion.

Angleworms have no eyes and do not see in the true sense of the word. Nevertheless they are quite sensitive to light, as may be seen when a bright light is flashed suddenly upon them at night; this usually causes instant withdrawal into the soil. The writer has found, however, that earthworms are comparatively insensitive to red light, even when it is rather strong. Blue light, on the contrary, affects them quickly. This sensitivity to light evidently is restricted largely to the head or the forward end of the body, as may be demonstrated by flashing a light on the worms as they begin to emerge from the ground. The worms are said to be deaf, but they are very sensitive to air currents, and especially so to the slightest vibration of the earth or of any object that happens to be in contact with their bodies. On nights when high winds prevail earthworms usually are absent on the surface of the ground even when conditions of temperature and moisture are favorable for their appearance.

A German zoologist recently made the statement that the common earthworms are capable of producing an audible sound which apparently is voluntary. This statement may be verified by anyone who will collect a dozen or more large earthworms and confine them in a suitable container, with sufficient earth to cover them. If, after the container with its worms has been kept in a dark place for some hours, it be quietly approached the sound referred to can be distinctly heard by a person having ordinarily good hearing. It can be closely imitated by moistening the lips well and then opening and closing them without moving the jaw. This action results in a snapping sound not unlike the dripping of water from a leaking faucet. It is well known that in Java there is a monstrous earthworm several feet in length called *Perichaeta musica* Horst, which during the night makes a sharp, interrupted sound, apparently by rubbing the bristles on its body against a stone. It is argued that, since these sounds evidently are produced voluntarily by the worms, this necessarily implies the possession of a sense of hearing. To judge from Darwin's experiments, the possession of this sense seems improbable, but the subject is still under investigation.

Although their sense organs appear to be poorly developed, earthworms were found by Darwin to exhibit a surprising degree of intelligence in choosing the most efficient methods of handling the various materials used

in plugging up the mouths of their burrows, and in lining the upper parts of them with leaves and similar substances.

FIG. 1.—The rainworm, *Lumbricus terrestris*. Natural size. (Hofmeister)

HOW EARTHWORMS REPRODUCE

Every earthworm is both male and female. Each worm produces eggs from the forward half of the body near the flesh-colored, swollen band that may be observed there. The eggs are deposited within a ring of gelatinous matter that quickly solidifies and is then slipped over the head and assumes the shape of a capsule. Such capsules contain several eggs, together with a quantity of albumin to serve as food. The young worms emerge from the capsule fully formed and ready for their struggle for existence. The egg capsules of the common, large earthworms are about the size of a grain of wheat, which they otherwise resemble, and are found commonly in the soil. Much is yet to be learned regarding them, how soon they hatch, the exact number laid, the rate of growth, etc. The young are said to become adults in about three or four months.

COMMON SPECIES OR KINDS OF EARTHWORMS

The largest of the earthworms[3] commonly found in this country is a species long known in Europe, where it is widely distributed. (Fig. 1.) A large worm of this kind when fully extended may measure 10 inches or more. When contracted, such worms may be slightly larger in diameter than an ordinary lead pencil. Because of the large size of this species and its fondness for locating in well-kept grass plots, where it may become numerous enough to loosen the roots of the grass and throw up unsightly hillocks of soil, it is of considerable economic importance. According to Frank Smith, an eminent American authority on earthworms, it is, however, not so widely distributed throughout this country as is a somewhat smaller kind,[4] which is able to thrive in a great variety of locations and is equally at home in the soil of undisturbed woodlands, cultivated fields, or even bottom lands along rivers. Doctor Smith says that there is scarcely one of the States where collections have been made in which this worm has not been found abundantly. It is indistinguishable from the larger species except by its generally smaller size and by technical

[3] *Lumbricus terrestris* L.

[4] *Helodrilus caliginosus* Savigny.

characteristics apparent only to an expert.

Among the common species of earthworms which are of no great economic importance is a slender, foul-smelling worm[5] ringed with maroon and yellow, which is found in old manure, compost heaps, and tanyards. (Fig. 2.) This species is known as the "brandling" in Great Britain, where it is an especial favorite of trout fishermen. It is commonly known in the United States as the manure worm or "stinking fishworm." Another common kind of earthworm is the green Helodrilus.[6] It is found in the Western Hemisphere from Greenland to Guatemala.

The largest earthworms inhabiting the eastern part of the United States do not much exceed 12 inches in length. The average length of 50 large worms collected in Maryland, near Washington, D. C., was 8 inches. In Africa (Natal), Ceylon, and Australia, however, are found giant earthworms which are from 3 to 6 feet long.

BLOODWORMS

There are two quite similar species of marine, or ocean-dwelling, worms commonly sold on the Atlantic seaboard as bait for salt-water and anadromus[7] fishes. Fishermen know these forms as "bloodworms" because of the considerable quantity of red blood with which the body cavity is filled. As they constitute a very effective bait, there is a regular commerce in these worms, and the bulk of the supply comes from the Atlantic shore of Long Island, particularly from the vicinity of Jamaica Bay. The wholesale dealers ship them packed in a seaweed known as "sea cabbage." They are placed in a closed container and kept in a refrigerator pending sale.

Bloodworms inhabit the sandy and muddy ocean beaches from low water mark to a depth of several fathoms. They have the habit of burrowing into the bottom by coiling themselves into a spiral like a corkscrew and rapidly revolving their bodies in a manner similar to the action of that supposedly obsolete instrument. Correspondents frequently inquire whether such worms can be cultivated and whether it is possible to feed them in captivity. These worms feed only

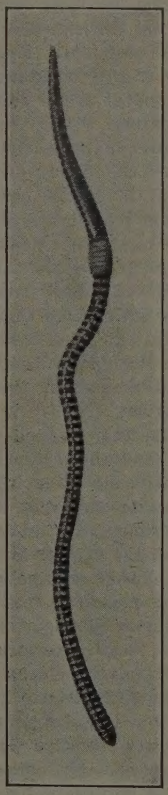

FIG. 2.—The brandling, or stinking earthworm, *Helodrilus foetidus*. Natural size. (Hofmeister)

[5] *Helodrilus foetidus* Savigny.
[6] *Helodrilus chloroticus* Savigny.
[7] Fishes which, at certain seasons, ascend rivers from the sea for breeding purposes.

on smaller marine animals in the ocean and can not be cultivated elsewhere or induced to feed in captivity.

USES OF EARTHWORMS

In addition to their value as an agency in the enrichment of the soil, earthworms contribute importantly if unwillingly to the sustenance of creatures that appeal to the aesthetic side of man's nature. They furnish food for song birds in the early spring, at a time when the supply of seeds and berries is at its lowest ebb and long before insect food becomes plentiful. Among the most appreciative patrons of this item of food is our familiar and well-beloved robin. The dexterity and facility with which this alert and vigorous bird can yank a large earthworm from its burrow is a source of wonder and amusement even to the casual observer.

Most of the various kinds of domestic poultry and their game-bird relatives feed to some extent upon earthworms. In this connection it has been shown experimentally that earthworms may swallow the eggs or larvae of the roundworm known as the gapeworm, which is the cause of gapes in chicks, and that when chicks eat earthworms which have these gapeworm eggs or larvae in them, the chicks may contract gapes. This disease has a high mortality for these young birds. Chicks are also infected by swallowing the gapeworm eggs or larvae quite apart from earthworms, but it is possible that earthworms are important as sources of infection with gapes. Recently it has been shown [8] that turkeys constitute a normal host for gapeworms and are largely responsible for the infection of chickens, entirely independent of earthworms, where these birds are permitted to run in company.

From time immemorial earthworms have been used by anglers as a lure for the taking of fresh-water fishes, and they constitute the most generally available and effective bait known for this purpose. The earliest published work in the English language on angling is entitled: "Fysshynge Wyth an Angle," and is said to have been written by Julia Berners, an English Benedictine nun, and was published in the Book of St. Albans in 1496. It contains explicit directions regarding the best kinds of worms for such uses and the places where they are to be sought.

Requests for information on finding and caring for earthworms are constantly being received by this department. Most inquiries of this kind relate apparently to the large rainworms or night crawlers, but, judging from the statements of correspondents, fishworms of any kind find a ready market throughout the summer-resort sections of the United States.

METHODS OF COLLECTING EARTHWORMS

The burrows of earthworms are often well concealed and, even where numerous, may not be noticed by the uninitiated. The worms have the habit of plugging the entrances to their tunnels with various materials, such as leaves, seeds, twigs, or pebbles, which remain until the inhabitants emerge. Some of these objects are known to serve as food, but others, such as pebbles, bits of concrete, and cherry stones, evidently have no such use. They aid in concealment, and possibly serve to exclude both the sunlight and some of their more insidious enemies, such as the centipedes mentioned elsewhere in this bulletin.

During the more humid portions of the year earthworms ascend to the surface of the soil in the evening, to feed and to mate, and very probably for purposes of migration. That they emerge in great numbers during rains at night and travel considerable distances is a fact that is obvious. Some observers believe that the worms are

[8] B. H. RANSOM, THE TURKEY AN IMPORTANT FACTOR IN THE SPREAD OF GAPEWORMS. U. S. Dept. Agr. Bul. 939, 13 p. 1921.

forced from their burrows to avoid drowning.

Although the common way of obtaining earthworms for angling purposes is by recourse to the shovel, garden fork, or mattock, this is by no means the easiest or most effective method of collecting them. They may be more readily gathered by means of a lantern or flash light, after dark, on almost any piece of well-fertilized sod, especially where there are a few large trees to furnish both leaves for food and shade from the summer sun. If a flash light be used it is well to subdue the light by covering the lens with tissue paper or a thin handkerchief, as the worms instantly withdraw into their burrows when too bright a light is flashed suddenly upon them, and not many creatures can move more quickly than a badly frightened earthworm. The best light for this purpose is a flash light fitted with a red glass, as red light does not frighten the worms.

It is claimed that there are several other successful methods of securing earthworms. Among these are tapping or hammering on the soil surface and the so-called "fiddling." Both of these methods doubtless are based on the fact that when soil containing earthworms is agitated this action induces some of the worms within the disturbed area to emerge from their burrows. In the first method an area of ground that bears evidences of the presence of earthworms is located. Then the collector hammers or knocks on its surface to induce the worms to emerge. A variation of this method is to drive a wooden stake into the soil to a depth of about 10 inches, and then to knock on the side of it until the worms come up. The writer, in Maryland, near the District of Columbia, has tried both of the latter plans without success. In this case the soil was a heavy clay, inhabited by a common large earthworm or night crawler. It is, of course, quite possible that in a different soil, or in the presence of other species of worms, favorable results could be obtained.

In the "fiddling" method, a stake similar to that already described is used, but, instead of knocking on it, the operator rubs the side of a thin board across the top of the stake. This produces in the stake a vibratory or shuddering action which is, in turn, transmitted to the soil. It is said that in Florida this method results in the immediate appearance of the worms within a radius of from 25 to 30 feet of the operator. In some other regions the method has been unsuccessful, and it seems highly probable that the trusty garden fork or the night-collecting method previously described will be found to bring more consistent and satisfactory results.

In dry weather earthworms descend more deeply into the soil, and come to the surface in smaller numbers at night. At such times, indeed, they may seem to be entirely absent. Usually, however, it will be found that if the soil around their burrows is thoroughly wetted down by sprinkling with a garden hose shortly before sundown, the worms will come eagerly to the surface after dark, provided the night temperature does not fall much below 40° F. In case it is desired to obtain earthworms during cold weather, they may usually be found by digging beneath compost heaps or manure piles. Earthworms are hardy creatures, and a brief period of mild weather brings them to the surface even in February, in the latitude of Washington, D. C. The writer has observed them mating in considerable numbers when the air temperature was 41° F.

The worms should be collected in a clean vessel, such as a fruit jar or a thoroughly cleansed tin can. They should not, however, be allowed to remain indefinitely in a metal container, as they survive much longer and in better condition when kept in an earthen crock or a tight wooden pail or box. The writer has found a 3-gallon stoneware crock, containing

about 8 inches of mellow earth covered with a 2-inch layer of plant material such as sphagnum moss, sods, or even common chickweed, excellent as a storehouse for 100 or more large earthworms. In such a container, kept in a cool corner of the cellar, the worms remain in good condition for weeks; and almost indefinitely when fed a little finely chopped raw beef suet, crumbled hard-boiled egg, or even finely divided bread crumbs. These may be sprinkled upon the surface of the soil in the container, underneath the plant material. Either sweet or sour milk may be fed, but becomes offensive unless the earth is changed frequently.

STORING AND REARING EARTHWORMS

Where it is desired to store or rear earthworms for sale, a larger container placed out of doors is desirable. For this purpose a tight box, preferably constructed of tongue-and-groove material, is suitable. It should be at least 18 inches deep and of a size proportionate to the number of worms it is proposed to handle. A box 18 by 36 by 60 inches will serve very well for several hundred large worms. If the exterior of the box is well tarred it will last much longer in the soil than if untreated. Creosote is not recommended for this purpose because of its possible effect on the worms. In any case the inside of the box should not be treated with either of these substances, but, if so desired, it may be waterproofed by painting with hot paraffin wax.

The box should be supplied with a well-fitting lid, which should project sufficiently over its edges to prevent flooding during heavy rains. It should be set into the soil with the upper 2 or 3 inches projecting above the surface, in a fairly well-drained place, and should be shaded to prevent the temperature of the interior from rising too high in midsummer. A temperature of 75° F. or higher is quickly fatal to earthworms under most conditions. The box should be nearly filled with good soil which is damp but not wet. The richer this soil is in humus the better, as the worms require less artificial feeding in rich soil than in poor. A loamy soil is preferable, but very sandy soil is not suitable.

After the box has been stocked with worms, the surface of the soil may be covered with a layer of cut sods if desired, but a very excellent covering consists of well-decayed leaves, which form a considerable part of the natural food of earthworms. In dry weather it will be necessary to moisten the soil in the box occasionally, but in doing so care should be taken to avoid flooding it, as too much water is injurious to the worms. Freezing kills earthworms, and in severe climates, where the soil commonly freezes to a depth of a foot or more during the winter, it may be necessary to protect the soil in the box from frost. Winter protection may be secured by giving the box a generous covering of half-decayed manure or compost.

Although under the conditions just described earthworms can live for a long time without artificial aid, it will be found desirable to feed them a little fat occasionally, in the form of chopped beef suet, or a little sugar in some cheap form. One dealer in earthworms claims to have been very successful in feeding worms ordinary molasses spread on the surface of gunny sacking or burlap, which is simply laid upon the soil with the sticky side down and moistened occasionally. The worms undoubtedly will reproduce more rapidly and be more thrifty if they are well fed. When the worms obtain insufficient food they shrink rapidly in size and lose vigor.

PREPARATION OF EARTHWORMS FOR ANGLING OR FOR MARKET

Although earthworms may be marketed or used freshly dug from the

ground, they are much more desirable, will live longer on the hook, and will take more fish if well "scoured" before use. This fact is well known to all skilled bait fishermen, and it is probable that the knowing ones would be willing to pay a premium for such worms. This scouring process has been known for hundreds of years and was well described by Izaak Walton in 1653.

To carry out this "scouring" process a quantity of sphagnum moss such as is used by nurserymen in packing plants for shipment is put into a stoneware crock or tight wooden box. This moss, which grows in shady, swampy woods, should be well moistened, but the excess water should be wrung out before the moss is placed in the container. The worms should be placed in the moss for at least two days, and preferably three or four, and kept in a cool place. At the end of this period they should be almost transparent, tough, and lively. In case it becomes necessary to keep them in the moss for some weeks, a little sweet milk should be poured over them at intervals of about a week, but the moss should be washed and wrung out in clean water every week or 10 days.

A PRACTICAL BAIT BOX

In warm weather the fisherman, while on the stream, often finds it a difficult matter to keep worms alive and in good condition. The ordinary tin or aluminum bait boxes, such as are commonly sold by tackle dealers, serve to conduct to the worms the heat of the sun as well as that of the fisherman's body. This heat may cause their death and thus deprive the angler of bait at a most interesting moment of the day's sport. Figure 3 illustrates a worm box, designed and constructed by the author, which has given perfect satisfaction over a period of two years. It is made of galvanized sheet iron and lined with sheet cork. This lining is one-fourth of an inch thick, and was given two heavy coats of collodion on the inside to make it waterproof and sanitary. The metal box is provided with a canvas jacket that is laced on, so that it may be easily removed for cleansing. In practice this jacket is kept wet, and the evaporation from it causes absorption of heat and keeps the worms cool and lively even on the hottest of summer days. Any tinsmith can construct the metal box, and the sheet cork may be obtained from a dealer in shoe findings. In case the collodion is not obtainable, an excellent substitute is celluloid dissolved in acetone. Old photographic celluloid films furnish a ready source of the former, and acetone is sold by nearly all drug stores and is cheap.

FIG. 3.—A bait box that keeps worms cool and alive in hot weather

NATURAL ENEMIES OF EARTHWORMS

In addition to the fisherman with his ever-ready garden fork and tin can, the earthworm has numerous natural enemies that are constantly on the alert. Song and game birds, as well as domestic poultry, patrol the meadows and woodlands during the day, while the ubiquitous toad, with his huge appetite and sticky, darting tongue, stalks earthworms ceaselessly during the early hours of spring and summer nights. Some of the smaller species of harmless snakes, especially

the common and widely distributed garter snakes, feed largely on earthworms at times. The Bureau of Biological Survey has identified earthworms in the stomachs of no fewer than 45 species of birds. The crow seems to get more egg capsules of the worms, and the jacksnipe, woodcock, starling, and robin seem to get more adult worms. Earthworms are an important item of food to the four species last named.

This warfare, however, is not confined to the mere surface of the soil. The earthworms are by no means safe even in the fastness of their underground burrows. Here they are pursued relentlessly by the voracious house fly, as it has a coat of downy yellow hairs upon its back and sides. This down is entirely absent in the house fly.

For a long time the manner of life of the cluster fly was unknown, but this problem was solved in 1908, by David Keilin, of the Quick Laboratory, at Cambridge, England. He found that the larva or maggot of this fly was parasitic upon certain species of earthworms.[11] The fly's eggs are deposited on or in the soil and hatch in from five to seven days. The minute maggots then seek the worms and bore into their bodies, where they continue to feed until eventually the worms are destroyed. Subsequent investigations

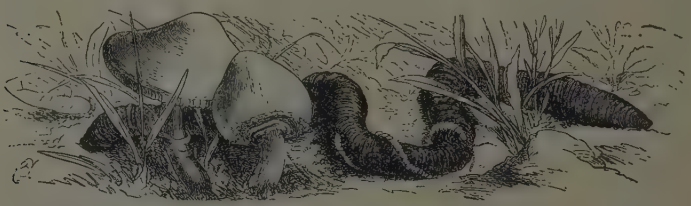

FIG. 4.—A centipede, a species of Geophilus, attacking a large earthworm. (Brehm)

shrews and moles, which subsist largely upon these creatures. Centipedes and "thousand leggers" follow the worms even to the depths of their longest tunnels. (Fig. 4.)

In addition to these formidable foes some kinds of earthworms have still another enemy in the form of a two-winged fly (fig. 5), which superficially resembles closely the common house fly.[9] In point of fact this insect, which is known as the cluster fly[10] and often enters houses in large numbers in the fall, is commonly mistaken for the house fly. By the use of a low-power magnifying glass, however, the cluster fly is easily distinguishable from the

carried on by American entomologists[12] confirmed in a general way these facts as applied to the life history of the insect in this country, but it was found that in summer the eggs hatch in about three days. It was found, also, that there may be several generations of the fly in a year[13] and that it is possible for the insect, under certain conditions, to undergo its complete cycle of development in from 27 to 39 days. The cluster fly itself falls a victim in great numbers to a fungous disease which attacks it during the warm, humid weather of midsummer. At this time even the newly emerged flies may be observed, stilled in life-

[9] *Musca domestica* L.

[10] *Pollenia rudis* Fab.

[11] *Helodrilus chloroticus* Savigny and *H. roseus* Savigny.

[12] WEBB, J. L., and HUTCHISON, R. H. A PRELIMINARY NOTE ON THE BIONOMICS OF POLLENIA RUDIS, FABR. IN AMERICA. Ent. Soc. Wash. Proc. 18: 197–199. 1916.

[13] GARRISON, G. L. REARING RECORDS OF POLLENIA RUDIS FAB. (DIPT.: MUSCIDAE.) Ent. News 35: 135–138. 1924.

like poses, attached to the leaves of plants, where they have been killed by the action of this fungous enemy.

GETTING RID OF EARTHWORMS WHERE THEY ARE A NUISANCE

IN LAWNS AND GOLF GREENS

Although, generally speaking, earthworms must be regarded as beneficial organisms, they often appear in places where they are objectionable. Many people object strenuously to their presence in lawns, especially where they become abundant enough to be very apparent. It is likely that in many cases this objection is founded upon a wrong conclusion. The worms by choice locate most abundantly in the dense shade of trees or shrubs, where, on account of the lack of sunlight, the grass grows but thinly or not at all. As the hillocks or heaps of castings produced by the worms are most obvious in such locations, the hasty conclusion is reached that the worms prevent the growth of the grass. They may, however, be nearly as plentiful, though unnoticed, in the dense turf, which continues to thrive in spite of their presence. It is true that the worms may occur in such numbers as to render the surface of the soil lumpy and thus interfere with the operation of a lawn mower. In such cases relief may be had by brushing or raking the lawn occasionally to break up and destroy the worm casts.

A similar condition of the soil, though much more serious, is produced in lawns throughout the southern half of the Eastern States late in the summer or in the fall by the boring of the grubs of the green June beetle.[14] Many persons mistake this work for the castings of earthworms, but the grubs make larger burrows and throw up much greater quantities of earth than do the worms. The burrows of these grubs may be distinguished from those of even the largest earthworms of this country by their somewhat larger size and the character and shape of the castings found about the mouths of the tunnels. Those of the grubs are shaped like a rectangular pillow or tablet, whereas the castings of the worms are always more or less spiral or vermicu-

FIG. 5.—The cluster fly. Enlarged 10 diameters

[14] *Cotinis nitida* L.

late. (Fig. 6.) In the latter part of summer and in the fall the grubs begin to burrow deeply into the soil for the winter, and where they are numerous at this time they become a real menace to the grass. The hillocks they create may measure 3 or 4 inches, or even more, in diameter. Frequently the grubs loosen the roots of the grass about their burrows sufficiently to kill it over a space several inches in diameter. The methods ordinarily recommended for the destruction of earthworms may have little effect on such

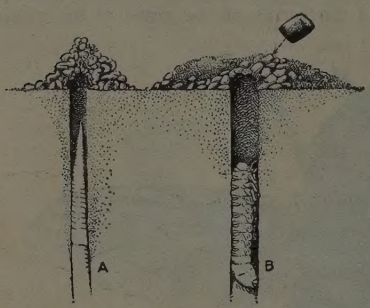

FIG. 6.—Comparison of A, burrow and castings of an earthworm, with B, burrow and castings of the grub of the green June beetle. Both about natural size

grubs. It is important, therefore, to ascertain whether the injury is caused by earthworms or by the grubs of the green June beetle before attempting to apply a remedy.[15]

The presence of earthworms on the putting greens of golf links is very objectionable, and in recent years attention has been paid to methods of destroying them in such locations.

Corrosive sublimate (bichloride of mercury) is the least expensive efficient vermicide thus far discovered, although several other poisons are more or less effective. R. A. Oakley, of the United States Department of Agriculture, has determined the dosage rather carefully and is responsible for the following suggestions:[16]

"From the standpoint of economy and efficiency, corrosive sublimate is without question the best substance to use to rid turf of earthworms. Furthermore, it is exceedingly efficient if properly used . . . there are many who have injured their turf by applying it improperly. Corrosive sublimate may be applied either in a water solution or mixed with sand or similar inert matter. The liquid form is regarded by many as preferable. . . .

"Two or not to exceed 3 ounces of corrosive sublimate dissolved in 50 gallons of water are sufficient for 1,000 square feet of green. After the solution is applied it should be followed with at least twice the quantity of water to wash it thoroughly into the soil. If it is desired to apply the corrosive sublimate dry, it should be mixed at the rate of 2 or 3 ounces to 2 cubic feet of dry sand, and the mixture scattered evenly over 1,000 square feet of green. Liberal watering should follow. When corrosive sublimate is applied in the way and at the rates suggested, especially if water is used freely afterward, no injury to the turf should result. In very hot, dry times applications as suggested may cause a very slight burning of the turf; and furthermore, it is rarely that earthworms are in action at such times. The effect of burning from the suggested rates, however, will not be lasting or serious."

In the case of comparatively small areas of grass an ordinary sprinkling pot may be used to apply the poison solution. As corrosive sublimate rapidly corrodes metals, the solution should not be allowed to stand in a metal container, and immediate washing is advised in case a sprinkling pot is utilized for this purpose. After the application of the solution the

[15] For methods of destroying green June beetles see the following: McKINNEY, K. B., and MILAM, J. THE GREEN JUNE BEETLE LARVA IN TOBACCO PLANT BEDS. U. S. Dept. Agr. Farmers' Bul. 1489, 6 p., illus. 1926.

[16] OAKLEY, R. E. EARTHWORMS. U. S. Golf Assoc. Green Sect. Bul. 4: 115–116. 1924.

worms usually begin to come to the surface within a very few minutes, and they should be gathered up and disposed of immediately. There is a possibility that if they are permitted to remain, some birds might be killed or injured by the poison left on the bodies of the worms.

CAUTION: Where corrosive sublimate is used it should be remembered that it is a dangerously poisonous substance and great care should be observed in handling it. All packages of the poison should be plainly labeled, and all vessels in which mixtures are made should be most scrupulously cleansed by washing after use.

The results of three years' application of ammonium sulphate to sod on the experimental farm of the Department of Agriculture at Arlington, Va., for fertilizing purposes, have shown incidentally that earthworms were eliminated from the plots where this chemical was used. When applied to soils which are naturally neutral or slightly acid in character, this fertilizer creates a strongly acid condition that is distasteful to the worms, and they disappear. Ammonium sulphate, either dissolved in water or mixed with dry sand, may be applied for this purpose at the rate of 3 pounds to 1,000 square feet of surface. In the case of strongly alkaline soils this treatment is not recommended, as it has little or no effect on the worms. This fertilizer should not be applied where it is desired to retain clovers in the sod, as these plants do not thrive in acid soils. It should be understood also that in any case the effect of ammonium sulphate on the worms is slow as compared with that of the highly active and poisonous bichloride of mercury.

Very recently it has been determined that powdered arsenate of lead, such as is in general use for insecticidal purposes, is efficient in destroying earthworms.[17]

Caution should be observed in applying arsenate of lead to some varieties of grasses. In the case of the various varieties of bent grass, such as are favored for use on golf greens, arsenate of lead has been found perfectly safe as a vermicide, but its application to annual bluegrass (*Poa annua*) and crabgrass has resulted in a decided check in the growth of these grasses. As a vermicide, the arsenate of lead may be applied at the rate of 1 pound to 1,000 square feet of surface. Uniform distribution is necessary, and may be obtained by mixing 1 pound of the dry arsenate with about 2 cubic feet of dry sand or loam, and broadcasting the mixture evenly over the ground. The application should be made when the grass is dry. This dose should be repeated every three of four weeks until the worms or the evidences of their presence disappear.

In very dry weather the worms will not come to the surface unless it is moist. For this reason the soil should be thoroughly sprinkled with a hose before any vermicide is applied.

In making new seedings of grass where worms are likely to be troublesome, the arsenate of lead should be worked into the soil to a depth of 1 or 2 inches.

Many of the proprietary vermicides contain mowrah meal as their active principle. This consists of the ground seeds of the madhuca tree of the East Indies from which the oil has been expressed. When fresh, this meal is an effective worm killer and may be applied to the grass in a dry condition at the rate of 15 pounds to 1,000 square feet of surface. The grass should then receive a liberal watering. Where this method of application is used there is no danger of burning. Mowrah meal deteriorates with age, especially when stored in a damp place, and is then ineffective. It has the advantage of being comparatively harmless to

[17] LEACH, B. R. FURTHER EXPERIMENTS IN THE CONTROL OF JAPANESE BEETLE GRUBS. U. S. Golf. Assoc. Green Sect. Bul. 8: 28–33, illus. 1928.

man and on this account is preferred for use on golf courses by some keepers.

IN FLOWERPOTS AND FLOWER BEDS [18]

Often the soil of flowerpots and flower beds becomes overstocked with earthworms, and in many cases injury to the plants results. The worms are brought in with the soil or manure and under favorable conditions multiply rapidly. Their habit of tunneling through the fine root system is often damaging or destructive to cultivated plants.

Limewater (saturated) applied freely to the soil will destroy earthworms and will not injure the plant. About 2 cupfuls of unslaked lime placed in a 3-gallon bucket of water, thoroughly agitated, and then allowed to settle, will furnish the desired clear liquid. Tobacco dust thoroughly worked into the soil is effective and at the same time has some value as a fertilizer.

Drenching the soil with a weak solution of mercuric chloride (corrosive sublimate), as is recommended for use out of doors, will destroy the worms. It may be prepared by dissolving one-half ounce of this chemical in 4 gallons of water. The caution is repeated that as corrosive sublimate is a deadly poison, it should be stored and handled with extreme care.

[18] Contributed by C. A. Weigel.

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